V. *Essay on a new Method of applying the Screw. By Mr.* William Hunter, *Surgeon; communicated by Lieutenant General* Melville, *F. R. S.*

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I HAVE some time ago been led to think, that the screw, which of all the mechanical powers is the most commonly employed in performing motions which require great accuracy, might be applied in a manner which would better answer many intentions than that commonly used. The plan is somewhat similar to NONIUS's division of the circle; but before I explain myself farther it may be proper to lay down a few general rules on which we may found a comparison.

The perfection of any machine consists in accomplishing the end proposed in a manner the most effectual, the most expeditious, and the least cumbersome possible. In order to attain this end the following things are required.

1. That the strength of the several parts of the engine be so adjusted to the force they are intended to exert, as that they shall not break under the weight they ought to counteract, nor yet encumber the motion by a greater quantity of matter than is necessary to give them a proper degree of strength.

2. That the increase of power, by means of the machine, be so regulated, that while the force we can exert is thereby rendered adequate to the effect, it may not be retarded in procuring it more than is absolutely necessary.

3. That

3. That the machine be as ſimple as is conſiſtent with other conditions.

4. That it be as portable and as little troubleſome in the application as poſſible.

5. That the contrivance be ſuch that the moving power may be applied in ſuch a way as to act to the greateſt advantage; and that the motion ultimately produced may have that direction and velocity which is moſt adapted to the execution of the deſign propoſed by the whole.

6. Of two machines, equal in other reſpects, that deſerves the preference in which the friction leaſt diminiſhes the effect propoſed by the whole.

It will eaſily appear, that ſome of theſe conditions, if carried to an extreme, will be inconſiſtent with ſome of the others. Here the proper medium conſiſts in adapting them to each other in ſuch a manner, as that the reſult of the advantages of both may be the greateſt, and that of the defects the leaſt, that is poſſible.

The following method of applying the ſcrew, I think, may in certain caſes be attended with ſome of theſe advantages to a greater degree than by thoſe commonly practiſed.

Let AB (fig. 1.) be a plate of metal in which the ſcrew CD plays, having a number of threads in an inch equal to a. Within the ſcrew CD there is a female ſcrew, by which is received the ſmaller ſcrew DE of $a+1$ threads in an inch. This ſcrew is retained from moving round along with the ſcrew CD by means of the apparatus at AFGB.

Now, if the handle CKL be turned a times round the ſcrew, CD will advance upwards an inch, and if we ſuppoſe the ſcrew DE to move round along with CD, the point E will alſo advance an inch. If we now turn the ſcrew DE a times backwards, the

point E will move downwards $\frac{a}{a+1}$ of an inch, and the reſult of both motions will be to lift the point E upward ($1 - \frac{a}{a+1} =$) $\frac{1}{a+1}$ of an inch. But if, while the ſcrew CD is turned a times round, DE be kept from moving, the effect will be the ſame as if it had moved a times round with CD and been a times turned back, that is, it will advance $\frac{1}{a+1}$ of an inch. At one turn therefore of the handle CKL it will move upwards ($\frac{1}{a+1} \times \frac{1}{a} =$) $\frac{1}{a^2+a}$ of an inch. If then we ſuppoſe the handle CKL to be b inches long, the power gained by the machine will be as $\overline{a^2+a} \times 6{,}2832\ b$ to unity.

To illuſtrate this by a particular example, let the ſcrew CD have 10 threads in an inch, and DE 11: then, while the handle CKL is turned 10 times round, the point D will riſe one inch above its former ſituation. But at 10 turns it can only paſs over 10 threads of the ſcrew DE, and conſequently it will advance upon that ſcrew $\frac{10}{11}$ths of an inch. The point E therefore muſt riſe $\frac{1}{11}$th of an inch, that the point D may have room to riſe a complete inch above its former place: therefore, at one turn of the handle, the point E will riſe $\frac{1}{110}$th of an inch; and if the handle be ſuppoſed half a foot long, the power, to produce an equilibrium, muſt be to the weight as 1 to $110 \times 6{,}2832 \times 6 = 4146{,}912$, which is the very number expreſſed by the general theorem, *viz.* $\overline{a^2+a} \times 6{,}2832\ b$, calling $a = 10$ and $b = 6$.

Now let us compare, according to the rules before laid down, this method of uſing the ſcrew with the common one. And, firſt, in order to have the ſame power by means of the common ſcrew that is exerted by this machine, it muſt have a number of threads

threads in an inch equal to a^2+a, which would render it too weak to resist any considerable violence. For example, if DC have five threads in an inch, and DE six, and if the handle CKL is a foot in length, the power gained by the engine will be nearly as $(\overline{a^2+a} \times 6\,b =)$ 2160 to 1; whereas, to have the same force by means of the common screw, it must have 30 threads in an inch, and so must yield under a resistance which the other screw would overcome without any difficulty. Upon this principle, the screw may be applied with advantage in presses of different kinds, by fixing one of the plates of the press to the end of the screw at E.

As to the second requisite, both methods may be equally adapted to it; yet other circumstances will determine us to apply the common screw where a small increase of power is necessary, and the present contrivance, when we stand in need of a greater.

This will follow from the third rule, as in the method now proposed a double number of screws is required, which makes the structure more complicated, occasions more expence, and requires a greater accuracy of construction, since, unless this is attended to, the machine will not move.

However, the machine may, in some cases, answer the fourth intention better than the common one, as the power gained by the additional screw enables us to shorten the handle which will tend to make the whole more portable.

The power is here applied in the same direction as in the common screw, so that both equally answer the first part of the fifth rule; but as to the last, the motion *ultimately* produced, it will depend on particular circumstances which of them is most fit for use in any case. Thus, if the screw DE be intended to carry an index which must turn round at the same time that it rises upwards, the common screw is preferable; for although I

can

can ſee a method by which the machine before deſcribed may be made to anſwer this purpoſe, I am almoſt afraid to propoſe it. I mean, that within the ſcrew DE another ſtill ſmaller ſhould be made to play, and be connected with the ſcrew CD, ſo as to move round along with it. It muſt have $a^2 + a + 1$ threads in an inch, and they muſt be in the contrary direction to thoſe of CD, ſo that when they are both turned together, and CD moves upwards, this other one may move downwards. At one turn of the handle this will move upwards $\frac{1}{a^2+a} \times \frac{1}{a^2+a+1} = \frac{1}{a^4+2a^3+2a^2+a}$ of an inch, and at the ſame time will move round in a circular direction. For example, let CD have 5 threads ($=a$) in an inch, DE 6 ($=a1$), and a third ſcrew within DE, but connected with CD ſo as to partake of its motion, 31 ($=a^2+a+1$). At one turn of the handle, this ſcrew will riſe upwards $\frac{1}{5} \times \frac{1}{6} \times \frac{1}{31} = \frac{1}{930}$ of an inch; but this appears too complicated for uſe, and the leaſt inaccuracy in the conſtruction would hinder it from moving.

But, on the other hand, if while the point E riſes it is of conſequence that it be kept from going round, the machine under conſideration will beſt anſwer this purpoſe. On this principle it may be uſeful in ſeveral reſpects: fot inſtance, let A (fig. 2.) repreſent a magnifying lens, and let it be moveable upon the ſcrew BC of 16 threads in an inch, which turns within the larger ſcrew CD of 15 threads in an inch, and that again moves within the plate EF in the end of the cylinder GF *. To uſe the inſtrument, fix the object to be magnified upon the pin GL, and then turn the lens A upon the ſcrew BC, till it be

* The ſcrew BC is reſtrained from moving along with CD by the ſmall pillar HK, which ſlides backwards and forwards in a groove in the cylinder GF.

nearly

nearly at the proper diſtance from the pin, and oppoſite to it. You may then adjuſt the diſtance more accurately by turning the ſcrew DC, at each turn of which the lens will recede from, or approach to, the pin $\frac{1}{240}$th of an inch. This it will do and not turn aſide, but ſtill remain oppoſite to the pin LG. A double microſcope might be fitted on in the place of the lens A. The whole inſtrument may be furniſhed with a handle, as at M; or, if larger, it may have three feet to ſtand on a table.

On the laſt principle it muſt be owned, the common ſcrew has the advantage, as two ſcrews will produce more friction than one; and, beſides, in the compound engine there is an additional friction from the piece FG (fig. 1.) upon the pillars between which it moves.

Another caſe in which this machine may be employed is in the micrometer. Thus, let the ſcrew AB (fig. 3.) of 50 threads in an inch be turned round by the index C, which moves upon the graduated circle ECD in the direction CD. Within the ſcrew AB is the ſmaller one AF of 51 threads in an inch, retained from moving round by the bar GFH. The piece AF is continued to K, where it forms a fine point. To uſe the inſtrument, let it be adjuſted to the teleſcope or microſcope by which you are to view a ſtar, or ſome ſmall object, and let the point K appear juſt to touch one edge of the object. Then turn the index C, and the point K will advance upwards till it appears to cover the other edge of the object, and thus you can determine its ſize. The point K will advance at each complete turn of the index $\frac{1}{2550}$ of an inch; and if the circle be divided into 80 equal parts, one of which, if it is an inch in diameter, will be very obſervable, while the index moves over one of theſe, the point K will advance $\frac{1}{204000}$ of an inch.

Thus, for example, ſuppoſe I am to meaſure the diameter of a nervous fibre in the medullary ſubſtance of the brain, I make the point K appear cloſe to one edge, and turn the index till the ſame point paſs over the fibre, and appear to touch the other edge: I then look on the graduated circle ECD, and perceive that the index C has paſſed over, ſuppoſe, 23,2 diviſions. Hence I conclude the diameter of the fibre to be $23,2 \times \frac{1}{204000} = \frac{1}{8790}$ of an inch, which is nearly the ſize as found by the accurate obſervations of Dr. MONRO. There ſhould be a NONIUS's ſcale on the index which will meaſure to one tenth of a diviſion.

As the index C muſt continue cloſe to the plate ECD, while at the ſame time it turns round the ſcrew AB, which is continually riſing, it muſt be made as in fig. 4. where *a*, *b*, are two ſmall pieces which play in a groove in the ſcrew AB (fig. 3.) while the groove CD (fig. 4.) in the index is filled up by a protuberance of the plate ECD (fig. 3.); the piece below the groove *cd* (fig. 4.) being ſunk into that plate. The whole machinery may be incloſed in a cylinder of braſs reaching from B to L (fig. 3.), ſo that the point of the ſcrew KL may be without it, and the ſides of the cylinder may be open at ECD.

It is farther to be obſerved, that what has been ſaid goes on the ſuppoſition that the point K, in the micrometer, is equally magnified with the object we are to meaſure. But, if this point be placed in the focus of the eye-glaſs of a double microſcope; when it moves it will paſs over, not the object itſelf, but its image, magnified by the object-glaſs. In this caſe, if the object-glaſs magnify the diameter 10 times, while the index paſſes over one diviſion, the point K will paſs over the image of an object, the diameter of which is $\frac{1}{2040000}$ of an inch. As in this mode of application the point K muſt fall between the

object

object and eye-glafs, the fcrews may be contained within the *fulcrum* by which the microfcope is fupported.

The machine (fig. 1.) may be applied as a jack to raife great weights a little way from the ground, by fubftituting two crofs hand-fpikes for the handle CKL; or a vertical handle may be employed in the following manner. Let A (fig. 5.) be a pinion turned by the handle AB, which we fuppofe a foot in length. Let the pinion A have 4 teeth, and move the wheel CD of 16 teeth. The fcrew EF of 4 threads in an inch is fixed in this wheel, and turns round along with it. Within it plays the fcrew FG of 5 threads in an inch, and which we fuppofe prevented from following the motion of EF: it terminates in fuch a fhoulder as that reprefented at G, and being continued to H ends in a foot as in the figure. The whole is inclofed in a ftrong frame. The pinion A muft be connected in fuch a manner with the wheel CD as to rife within the frame along with it, which may eafily be done by making its axis play in a piece of wood or metal, which is connected by the end to the fcrew EF. Or, if this fhould be deemed inconvenient, as the rifing of the pinion muft raife the handle AB, the wheel CD may be hindered from rifing, and at the fame time turn the fcrew EF, by a contrivance fimilar to that ufed with the index C (fig. 3.) in the micrometer. In either cafe, the axis of the pinion fhould be continued through the oppofite fide of the frame, and armed with a heavy fly to regulate the motion. When the machine is to be applied to ufe, the bottom of the frame refting on the ground, if the body to be lifted is already as high as the top G, that top is applied below it; but if it is clofe to the ground, we put below it the foot H; then, if the handle AB be turned once round, the wheel CD and fcrew EF will turn $\frac{1}{4}$ part round, and the point F will rife ($\frac{1}{4} \times \frac{1}{4} =$) $\frac{1}{16}$th of an inch. The point G or H will

therefore

therefore be lifted upwards ($\frac{1}{16} \times \frac{1}{5} =$) $\frac{1}{80}$th of an inch. But the end B of the handle AB has defcribed above fix feet; therefore the velocity of the point G is to that of the point B as one to ($72 \times 80 =$) 5760. Therefore, if we fuppofe a man to act at the handle with a force equal to 30 lbs. he may keep in equilibrio a weight of 172800 lbs. But a fubduction of perhaps more than one half of this muft be made, that he may raife the weight, as the friction of the engine will be confiderable. Suppofe it to be two-thirds, the effect ftill remains equal to 57600 lbs. or 25 tons 14 cwts. and 32 lbs.

It will eafily appear, that this method of applying the fcrew may have a place in many other engines, particularly where great accuracy is required; or we want a motion to be performed with great power, while at the fame time it need not have any large compafs. The few examples given above may ferve as a fpecimen.

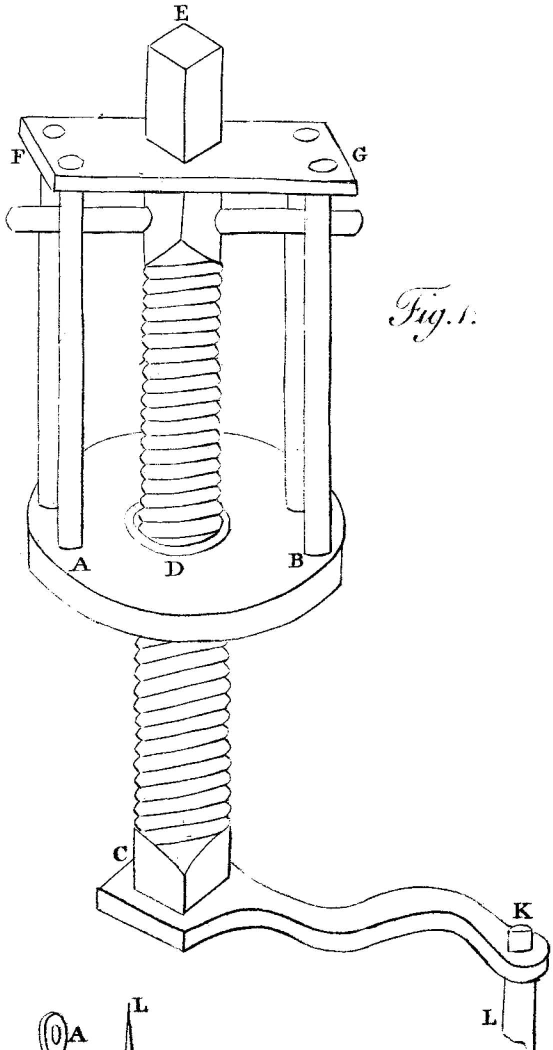

Fig. 1.

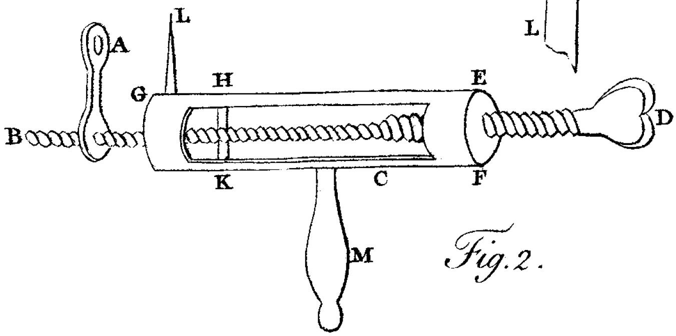

Fig. 2.

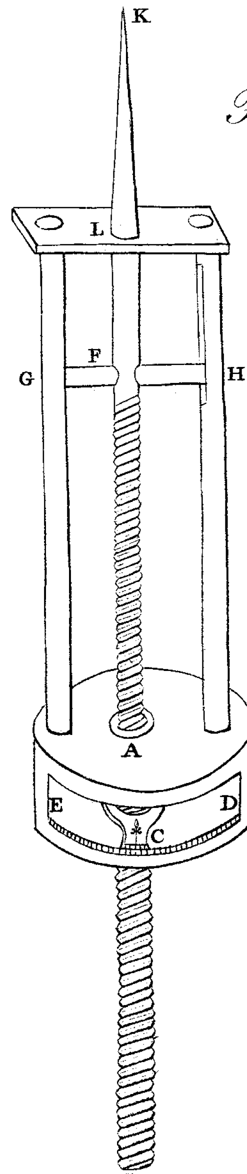

Fig. 3.

Fig. 4

Fig. 3.

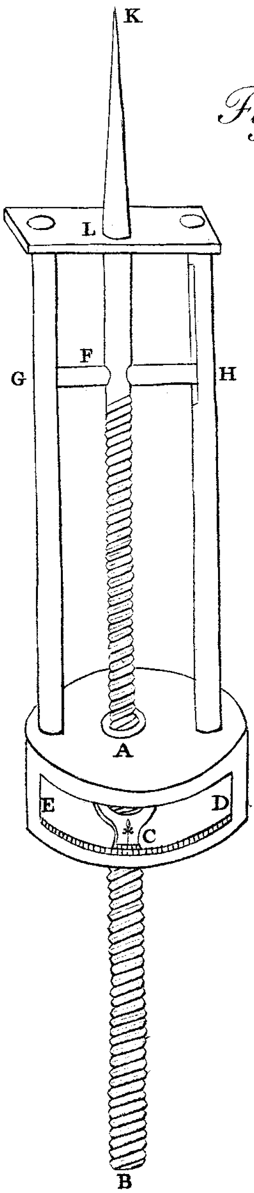

Fig. 4.

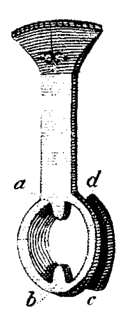

Fig. 5.